

CLAIMS

1. An azimuth measuring device comprising:
 - 5 earth magnetism detection means with 2 or 3 axes for detecting earth magnetism;
 - 10 output data acquisition means for acquiring 2-axis output data when the orientation of said earth magnetism detection means changes while keeping the detection directions of said two axes on a predetermined plane or 3-axis output data when the orientation of said earth magnetism detection means changes in a three-dimensional space repeatedly a predetermined number of times or more;
 - 15 reference point estimation means for defining a reference point on a two-dimensional coordinate system whose coordinate values correspond to said 2-axis output data or on a three-dimensional coordinate system whose coordinate values correspond to said 3-axis output data and estimating the coordinates of reference point using a statistical technique so that a variation in the distance from the 2-axis or 3-axis output data group acquired by said output data acquisition means to the reference point becomes a minimum; and
 - 20 offset information calculation means for calculating offset information with respect to the output data of said earth magnetism detection means based on said coordinates of reference point.

2. The azimuth measuring device according to claim 1,
characterized in that said reference point estimation means
comprises:

coefficients and constant term calculation means for
5 calculating coefficients and constant terms of simultaneous
linear equations whose unknowns are said coordinates of
reference point from said 2-axis or 3-axis output data group;
and

simultaneous linear equation analysis means for
10 estimating said coordinates of reference point by calculating
solutions to said simultaneous linear equations including said
coefficients and constant terms.

3. The azimuth measuring device according to claim 1,
15 characterized in that said earth magnetism detection means
is 3-axis earth magnetism detection means, and

when a degree of the variation of the output data group
is a predetermined value or below with respect to the output
data group of the axis whose degree of variation is a minimum
20 out of the 3-axis output data group, said reference point
estimation means defines a reference point on a two-dimensional
coordinate system whose coordinate values correspond to the
2-axis output data for the 2-axis output data group which is
generated by excluding the output data group of the axis whose
25 degree of variation is a minimum from said 3-axis output data
group and estimates said coordinates of reference point from
said 2-axis output data group.

4. The azimuth measuring device according to claim 1,
characterized in that said reference point estimation means
comprises:

first difference calculation means for calculating a
5 difference between a maximum value and minimum value of output
data in the output data group of each axis from said 2-axis
or 3-axis output data group; and

first difference decision means for deciding whether the
difference calculated by said first difference calculation
10 means is equal to or greater than a predetermined value or
not, and

said reference point estimation means uses said 2-axis
or 3-axis output data group for estimating said reference point
only when the difference calculated by said first difference
15 calculation means is equal to or greater than a predetermined
value.

5. The azimuth measuring device according to claim 1,
characterized in that said offset information calculation
20 means comprises:

variation calculation means for calculating a variation
at a predetermined number of the latest reference points
calculated by said reference point estimation means, and

said offset information calculation means discards the
25 reference point calculated by said reference point estimation
means based on the calculation result of said variation
calculation means.

6. The azimuth measuring device according to claim 5,
characterized in that said variation calculation means
calculates the difference between the two latest reference
points calculated by said reference point estimation means.

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7. The azimuth measuring device according to claim 1, further
comprising:

second variation calculation means for calculating a
variation at a predetermined number of the latest reference
points calculated by said reference point estimation means;
and

acceptability information creation means for creating
acceptability information regarding the acceptability of said
offset information based on the calculation result of said
second variation calculation means.

8. The azimuth measuring device according to claim 7,
characterized in that said acceptability information creation
means divides the degree of acceptability of said offset
information into a plurality of categories, classifies the
offset information into any one of said categories according
to the degree of variation calculated by said second variation
calculation means and displays the degree of acceptability
corresponding to the category.

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9. The azimuth measuring device according to claim 1,
characterized in that said offset information calculation
means comprises:

distance calculation means for calculating the distance from said output data group to said reference point; and

distance decision means for deciding whether the distance calculated by said distance calculation means is outside a
5 predetermined range or not, and

said offset information calculation means discards the output data group when the distance calculated by said distance calculation means is outside the predetermined range.

10 10. The azimuth measuring device according to claim 1, further comprising:

second distance calculation means for calculating the distance from said output data group to said reference point; and

15 reliability information creation means for creating reliability information regarding the reliability of the azimuth measurement result based on the distance calculated by said second distance calculation means.

20 11. The azimuth measuring device according to claim 10, characterized in that said reliability information creation means divides the degree of reliability of said azimuth measurement result into a plurality of categories, compares the distance calculated by said second distance calculation means with a plurality of thresholds, classifies the distance into any one of said categories and displays the degree of reliability corresponding to the category.
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12. The azimuth measuring device according to claim 1,
characterized in that said data output acquisition means
comprises:

third difference calculation means for calculating a
5 difference between the output data output from said earth
magnetism detection means and a predetermined number of pieces
of immediately preceding output data acquired by said output
data acquisition means or the output data output immediately
before from said earth magnetism detection means; and

10 third difference decision means for deciding whether the
difference calculated by said third difference calculation
means is smaller than a predetermined value or not, and

15 said output data acquisition means does not acquire but
discards the output data output from said earth magnetism
detection means when the difference calculated by said third
difference calculation means is smaller than the predetermined
value.

13. An azimuth measuring method including:

20 a step of changing detection directions of two axes for
measurement of earth magnetism while keeping the detection
directions of two axes on a predetermined plane or changing
the detection directions of three axes in a three-dimensional
space;

25 a step of acquiring the 2-axis or 3-axis output data for
measurement of earth magnetism when said detection directions
change;

a step of deciding whether said output data is acquired a predetermined number of times or more or not;

a step of defining a reference point on a two-dimensional coordinate system whose coordinate values correspond to said
5 2-axis output data or on a three-dimensional coordinate system whose coordinate values correspond to said 3-axis output data and estimating the coordinates of reference point using a statistical technique so that a variation in the distance from the output data group consisting of the 2-axis or 3-axis output
10 data acquired said predetermined number of times or more to the reference point becomes a minimum; and

a step of calculating offset values with respect to said 2-axis or 3-axis output data based on said estimated coordinates of reference point.

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14. The azimuth measuring method according to claim 13, characterized in that said step of estimating the coordinates of reference point comprises:

a step of calculating coefficients and constant terms
20 of simultaneous linear equations whose unknowns are said coordinates of reference point from said 2-axis or 3-axis output data group; and

a step of calculating solutions to said simultaneous linear equations including said coefficients and constant
25 terms and estimating said coordinates of reference point.

15. The azimuth measuring method according to claim 13, characterized in that said step of changing said detection

direction is intended to change detection directions of three axes in a three-dimensional space, and

said step of estimating the coordinates of reference point comprises:

5 a step of calculating the degree of variation of output data of the output data group of each axis of said 3-axis output data group and obtaining the axis corresponding to the minimum degree of variation and a minimum value of said degree of variation,

10 a step of deciding whether said minimum value of the degree of variation is equal to or lower than a predetermined value or not; and

 a step of defining, when said minimum value of the degree of variation is equal to or lower than the predetermined value,

15 a reference point on a two-dimensional coordinate system whose coordinate values correspond to the 2-axis output data for the 2-axis output data group wherein the output data group of the axis whose degree of variation becomes a minimum is excluded from said 3-axis output data group and estimating
20 said coordinates of reference point from said 2-axis output data group.

16. The azimuth measuring method according to claim 13,
characterized in that said step of estimating the coordinates
25 of reference point comprises:

 a step of calculating the difference between a maximum value and minimum value of output data of the output data group of each axis of said output data group;

a step of deciding whether the difference between said maximum value and minimum value is equal to or greater than a predetermined value or not; and

5 a step of estimating said coordinates of reference point when said difference between the maximum value and minimum value is equal to or greater than the predetermined value.

17. The azimuth measuring method according to claim 13, characterized in that the step of calculating offset values
10 with respect to said 2-axis or 3-axis output data comprises:

a step of calculating a variation at a predetermined number of the latest reference points calculated in the step of estimating the coordinates of reference point; and

15 a step of discarding the reference point calculated in the step of estimating the coordinates of reference point based on the calculation result of said variation.

18. The azimuth measuring method according to claim 13, further comprising:

20 a step of calculating a variation at a predetermined number of said estimated latest coordinates of reference points; and

a step of creating acceptability information regarding the acceptability of the offset values calculated in said step of calculating said offset values based on the calculation
25 result of said variation.

19. The azimuth measuring method according to claim 13,
characterized in that the step of calculating offset values
with respect to said 2-axis or 3-axis output data comprises:

a step of calculating the distance from said output data
5 group to said reference point;

a step of deciding whether the distance from said output
data group to said reference point is outside a predetermined
range or not; and

10 a step of discarding the output data group when the
distance from said output data group to said reference point
is outside the predetermined range.

20. The azimuth measuring method according to claim 13,
further comprising a step of calculating the distance from
15 said output data group to said reference point; and

a step of creating reliability information regarding the
reliability of the azimuth measurement result based on said
distance calculation result.